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NIXON PEABODY LLP
161 N. CLARK STREET
48TH FLOOR
CHICAGO, IL 60601-3213

EXAMINER	
LE, HUYEN D	
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UNITED STATES PATENT AND TRADEMARK OFFICE

BEFORE THE BOARD OF PATENT APPEALS
AND INTERFERENCES

Ex parte AART ZEGER VAN HALTEREN,
WILMINK ENGBERT, HENDRIK DOLLEMAN
and PAUL CHRISTIAAN VAN HAL

Appeal 2007-4432
Application 09/980,430
Technology Center 2600

Decided: June 10, 2008

Before ROBERT E. NAPPI, JOHN A. JEFFERY,
and CARLA M. KRIVAK, *Administrative Patent Judges*.

JEFFERY, *Administrative Patent Judge*.

DECISION ON APPEAL

Appellants appeal under 35 U.S.C. § 134 from the Examiner's rejection of claims 8-11 and 27-36.[1] We have jurisdiction under 35 U.S.C.

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[1] Contrary to the Appeal Brief filed February 16, 2006 (App. Br. 2), claims 12-26 have been withdrawn from consideration and are not canceled. The Advisory Action, mailed September 2, 2004, indicates the Amendment

§ 6(b). We affirm-in-part and enter a new ground of rejection under 37 C.F.R. § 41.50(b).

STATEMENT OF THE CASE

Appellants invented a coil assembly for an electro-acoustic transducer. The assembly includes a coil having an opening defining a longitudinal axis and an electronic circuit board positioned against and adhered to the coil in essentially perpendicular relationship to the axis. The circuit board may include electronics for signal processing. This assembly reduces the labor and time involved in constructing the transducer.[2]

Claim 8 is illustrative:

8. A coil assembly for an electroacoustic transducer, comprising:

> a coil having a coil opening defining an axis therethrough; and
>
> an electric circuit board wherein at least a surface portion thereof is positioned against said coil in a substantially perpendicular relationship to said axis.

The Examiner relies on the following prior art references to show unpatentability:

Sone	US 5,432,758	Jul. 11, 1995
Lee	US 5,861,686	Jan. 19, 1999

under 37 C.F.R. § 1.116, filed July 19, 2004, has not been entered for purposes of appeal.

[2] *See generally* Spec. 2:1-3:6 and 4:14-5:6.

The following reference is cited in a new ground of rejection under 37 C.F.R. § 41.50(b):

"Linear Transverters for 144 and 220 MHz" *in The ARRL Handbook For Radio Amateurs 1993*, ch. 31, pp. 31-17 through 31-28 (Am. Radio Relay League) (17th ed. 1992).

The Examiner's rejections are as follows:

1. Claim 28 stands rejected under 35 U.S.C. § 112, ¶2.
2. Claims 8, 9, 31, and 32 stand rejected under 35 U.S.C. § 102(b) as being anticipated by Lee.
3. Claims 8, 10, 11, 27, 29-31, and 33-36 stand rejected under 35 U.S.C. § 102(b) as being anticipated by Sone.[3]

Rather than repeat the arguments of Appellants or the Examiner, we refer to the Briefs[4] and the Answer[5] for their respective details. In this decision, we have considered only those arguments actually made by Appellants. Arguments, which Appellants could have made but did not make in the Briefs, have not been considered and are deemed to be waived. *See* 37 C.F.R. § 41.37(c)(1)(vii).

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[3] The rejections of claim 8 under 35 U.S.C. § 102(a) as being anticipated by Kuwabara (US Patent 6,023,518) and claims 9, 10, 29 and 31-33 under 35 U.S.C. § 103(a) as being unpatentable by Kuwabara have been withdrawn (Ans. 6). Additionally, the rejection of claims 9 and 32 under 35 U.S.C. § 102(b) as being anticipated by Sone has been withdrawn (Ans. 6).

[4] We refer to the most recent Appeal Brief, filed February 16, 2006, and the most recent Reply Brief, filed July 24, 2006, throughout this opinion.

[5] We refer to the most recent Examiner's Answer mailed May 19, 2006, throughout this opinion.

OPINION

The Indefiniteness Rejection

We first consider the Examiner's rejection of claim 28 under 35 U.S.C. § 112, ¶ 2 as being indefinite for failing to particularly point out and distinctly claim the subject matter which Appellants regard as the invention. The Examiner finds claim 28 is indefinite because it depends from withdrawn claim 12 (Ans. 3). Appellants argue that the non-entered Amendment[6] changing the dependency to claim 27 overcomes the rejection (App. Br. 4).

At the outset, we note that claim 12 has been withdrawn from consideration as being drawn to a non-elected invention.[7] Similarly, claim 28 should have been withdrawn from consideration.[8] Additionally, claim 12 recites that a surface portion of the electric circuit board is positioned against the coil by adhesion, and claim 28 further limits the type of adhesion to glue. There is a reasonable degree of clarity and particularity with regards to the recitation in claim 28 regarding the type of adhesion, and we see no ambiguity.

For the foregoing reasons, we will not sustain the Examiner's indefiniteness rejection of claim 28.

The Anticipation Rejection Based on Lee

We next consider the Examiner's rejection of claims 8, 9, 31, and 32 under 35 U.S.C. § 102(b) as being anticipated by Lee. "A claim is

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[6] *See* the Advisory Action, mailed September 2, 2004.
[7] *See* Paragraph 6 of the Non-Final Office Action mailed August 27, 2003.
[8] *See* 37 C.F.R. § 1.142(b) and MPEP § 821.

anticipated only if each and every element as set forth in the claim is found, either expressly or inherently described, in a single prior art reference." *Verdegaal Bros, Inc.. v. Union Oil Co. of Calif.*, 814 F.2d 628, 631 (Fed. Cir. 1987). Appellants group the arguments according to the following claims: (1) 8 and 9 and (2) 31 and 32 (App. Br. 9-10; Reply Br. 4-5). Below, each group will be addressed.

Claims 8 and 9

Regarding representative independent claim 8,[9] the Examiner indicates that Lee discloses all the claimed subject matter (Ans. 3). Appellants argue that element 3b in Lee is not an electronic circuit board. Specifically, Appellants contend the recited electric circuit board in Lee is not shown and that the purpose of element 3b is to vibrate in response to a given frequency sent by the printed circuit board not shown (App. Br. 9-10).

Lee discloses the second vibration element 3b is "also used as a circuit board for the coil 8" (Lee, col. 3, ll. 50-51 and col. 4, l. 17). This disclosure clearly states that element 3b serves two functions – one as a vibration member to generate sounds (Lee, col. 5, ll. 15-16) and another as a circuit board for the coil (Lee, col. 3, ll. 49-51 and col. 6, ll. 10-16). Additionally, Lee discloses two circuit boards: (1) the vibration element 3b and (2) the printed circuit board for the cellular or pager phone (Lee, col. 4, ll. 15-17). The fact that more than one circuit board is disclosed does not detract from the explicit disclosure in Lee that element 3b is a circuit board for the coil

[9] Appellants argue claims 8 and 9 as a group (App. Br. 9-10; Reply Br. 4). Accordingly, we select claim 8 as representative. *See* 37 C.F.R. § 41.37(c)(1)(vii).

(Lee, col. 3, ll. 41-51) and fully meets the limitation to an electric circuit board in claim 8.

For the foregoing reasons, Appellants have not shown error in the anticipation rejection of independent claim 8 based on Lee. Accordingly, we sustain the rejection of claim 8 and claim 9 which falls with claim 8.

Claims 31 and 32

Regarding representative independent claim 31,[10] Appellants argue that Lee does not include signal processing electronics (Reply Br. 4). This argument was not timely raised in the Appeal Brief, but rather was brought up for the first time in the Reply Brief. As such, this argument is waived.[11] In any event, the respective electric circuit board in Lee (member 3b) includes electronics which are used to convert or process the electrical signals into acoustic energy (Lee, col. 3, ll. 41-51, col. 4, ll. 7-17, col. 5, ll. 38-44, and col. 6, ll. 10-16). Additionally, given the breadth of the recited "signal processing electronics" limitation, the electronics of the electric circuit board 3b in Lee that convert and process the electric signals to acoustic energy amply disclose signal processing electronics.

For the foregoing reasons, Appellants have not shown error in the anticipation rejection of independent claim 31 based on Lee. Accordingly, we sustain the rejection of claim 31 and claim 32 which falls with claim 31.

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[10] Appellants argue claims 31 and 32 as a group (Reply Br. 4-5). Accordingly, we select claim 31 as representative. *See* 37 C.F.R. § 41.37(c)(1)(vii).

[11] *See Optivus Tech., Inc. v. Ion Beam Appls. S.A.,* 469 F.3d 978, 989 (Fed. Cir. 2006) ("[A]n issue not raised by an appellant in its opening brief … is waived.") (citations and quotation marks omitted).

The Anticipation Rejection Based on Sone

We finally turn to the Examiner's rejection of claims 8, 10, 11, 27, 29-31, and 33-36 under 35 U.S.C. § 102(b) as being anticipated by Sone. Appellants group the arguments according to the following: (1) claims 8, 10, and 30; (2) claims 11 and 34; (3) claims 27 and 35; (4) claims 29, 31, and 33 (App. Br. 5-9; Reply Br. 2-4); and (5) claim 36. Below, each group will be addressed.

Claims 8, 10, and 30

Regarding representative claim 8,[12] the Examiner's rejection finds that Sone discloses all the claimed subject matter (Ans. 4). Appellants argue that Sone does not disclose an electronic circuit board. Specifically, Appellants take the position that plate 40 in Sone is part of a closed magnetic circuit and that none of the elements selected by the Examiner (40, 42, 44, 48, 50, 52) make up an electric circuit board. In Appellants' view, the electric circuit board in Sone is actually designated by element 62 and is not positioned against the coil as claimed (App. Br. 5-7; Reply Br. 3).

Sone discloses a plate 40 insulated by film 48 that includes conductive patterns 50 and 52 (Sone, col. 4, ll. 10-43; Figs. 1-4). The conductive patterns 50 and 52 are printed on both sides of the plate 40 and create circuitry used for mounting and interconnecting components of electrical equipment (Sone, col. 4, ll. 31-43 and col. 6, ll. 65-67). The film 48 insulates the patterns 50 and 52 from the plate 40 (Sone, col. 4, ll. 28-31 and

[12] Appellants argue claims 8, 10, and 30 as a group (App. Br. 5-8). Accordingly, we select claim 8 as representative. *See* 37 C.F.R. § 41.37(c)(1)(vii).

col. 6, ll. 15-19). Hence, the plate 40, film 48, and patterns 50 and 52 all interconnect structurally to form an electric circuit board. Moreover, there is nothing in the Specification that excludes the recited electric circuit board from comprising multiple interconnected structural elements, such as a laminate. Thus, the broadest reasonable construction of the term, “electric circuit board,” in light of the Specification would include such multiple interconnected structural elements. Additionally, irrespective of the Examiner’s statement that the printed circuit board 62 “is not included in the Office Action” (Ans. 6), the circuit board 62 along with the plate 40, film 48, and patterns 50 and 52 all make up parts of an electric circuit board as the printed circuit board 62 in Sone is soldered and electrically connected to the plate (Sone, col. 6, ll. 24-27; Fig. 5). Moreover, as the plate 40 also has a surface portion (top surface of 40 shown in Figure 1) positioned against the coil in a substantially perpendicular manner, Sone discloses at least a surface portion of an electric circuit board positioned against the coil in a substantially perpendicular relationship to the axis defined by the coil opening as recited in claim 8.

Appellants also argue that the plate 40 is part of the closed magnetic circuit and cannot be a part of an electric circuit board (App. Br. 5-6; Reply Br. 3). As previously stated, we disagree that the plate cannot be part of the electric circuit board. That is, the plate 40 serves more than one function. While acting as part of the magnetic circuit, the plate additionally serves as a substrate or base for printing the insulating film and the conductive patterns -- all of which define the electric circuit board. The plate, therefore, forms a portion of an electric circuit board.

For the above reasons, Appellants have not shown error in the anticipation rejection of claim 8 based on Sone. Accordingly, we sustain the rejection of claim 8 and claims 10 and 30 which fall with claim 8.

Claims 11 and 34

Representative claim 11[13] further recites the electric circuit board has an opening and the opening is substantially aligned with the coil opening. The Examiner indicates how this limitation is fully met by Sone (Ans. 4). Appellants repeat the arguments made regarding claim 8 and the plate 40 in Sone not being an electric circuit board (App. Br. 8). In Appellants' view, since the plate 40 is not an electric circuit board, Sone does not disclose the electric circuit board has an opening (App. Br. 8). Our previous discussion pertaining to the disclosure of Sone and how the plate 40 is part of an electric circuit board applies equally here. We, therefore, incorporate that discussion by reference. As the plate 40 makes up a portion of the electric circuit board in Sone, the circuit board includes an opening (Sone, col. 5, ll. 19-20; Fig. 1) substantially aligned with the coil opening as recited in claim 11.

For the above reasons, Appellants have shown no error in the anticipation rejection of claim 11 based on Sone. Accordingly, we will sustain the anticipation rejection of claim 11 and claim 34 which falls with claim 11.

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[13] Appellants argue claims 11 and 34 as a group (App. Br. 8). Accordingly, we select claim 11 as representative. *See* 37 C.F.R. § 41.37(c)(1)(vii).

Claims 27 and 35

Claim 27 further recites the surface portion of the electric circuit board is positioned against the coil by adhesion. Claim 8, from which claim 27 depends, also recites the surface portion is positioned against the coil in a substantially perpendicular relationship to the axis defined by the coil opening. The Examiner indicates how this limitation is fully met by Sone through the connection of the lead wires 22 and 24 to coil and plate (Ans. 4). Appellants argue that the core 6, not the coil, is adhered or connected to the plate 40 by a screw. Based on this disclosure, the Appellants contend that Sone does not disclose the surface portion of the electric circuit board is positioned against the coil by adhesion (Reply Br. 4). Although this argument was raised for the first time in the Reply Brief and is technically waived,[14] we nonetheless address this contention. Upon review, we find that Sone does not disclose or is silent regarding whether *the surface portion* of the electric circuit board that is positioned against the coil in a substantially perpendicular relationship to the axis defined by the coil opening is also positioned against the coil by adhesion.

Based on the above reasons, we will not sustain the anticipation rejection of claim 27 and claim 35 which is commensurate in scope.

[14] *See Optivus,* 469 F.3d at 989.

Claims 29, 31 and 33

Representative claim 29[15] further recites the electric circuit board includes electronics for signal processing. The Examiner indicates how this limitation is fully met by Sone (Ans. 4). Appellants argue that the plate 40, film 48, and conductive patterns 50 and 52 do not include electronics for signal processing (App. Br. 7-8; Reply Br. 3).

We agree with Appellants that components 40, 48, 50, and 52 in Sone are not electronics for signal processing. However, as stated above with regard to claim 8, the scope and breadth of the recited electric circuit board does not preclude multiple interconnected structural elements that include circuit board 62 in Sone. That is, Sone discloses an electric circuit board that includes plate 40, film 48, patterns 50 and 52, *and* board 62. Sone discloses the device converts electrical signals to sound, and thus the board 62 must include some electronics for signal processing (Sone, col. 1, ll. 6-9). Additionally, Appellants admit that any electronics in Sone would be on the printed board 62 (Reply Br. 3). In turn, component 62 of the electric circuit board in Sone includes electronics for signal processing as claim 29 recites.

For the above reasons, Appellants have not shown error in the anticipation rejection of claim 29 based on Sone. Accordingly, we sustain the rejection of claim 29 and claims 31 and 33 which fall with claim 29.

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[15] Appellants argue claims 29, 31 and 33 as a group (App. Br. 7; Reply Br. 4-5). Accordingly, we select claim 29 as representative. *See* 37 C.F.R. § 41.37(c)(1)(vii).

Claim 36

Claim 36 further recites the electric circuit board is electrically connected to the coil through lead wires. The Examiner indicates how this limitation is fully met by Sone (Ans. 5). Appellants argue that the board 62 is not electrically connected to the coil through lead wires but rather through soldering the board 62 to plate 40 (App. Br. 9). Our previous discussion pertaining to Sone and how the plate 40, film 48, patterns 50 and 52, and board 62 are parts of the electric circuit board applies equally here. We, therefore, incorporate that discussion by reference. As the plate 40 and conductive patterns 50 and 52 of Sone are part of the electric circuit board, Sone discloses a portion of the electric circuit board is electrically connected to the coil through lead wires 22 and 24 as recited in claim 36 (Sone, col. 6, l. 61 – col. 7, l. 5; Figs. 1, 3 and 5).

Based on the above reasons, Appellants have not shown error in the anticipation rejection of claim 36 based on Sone. Accordingly, we sustain the rejection of claim 36.

New Grounds of Rejection Under 35 U.S.C. §102(b)

Under 37 C.F.R. § 41.50(b), we enter a new ground of rejection under 35 U.S.C. §102(b) for claims 8, 27, 29, 31, and 35.

The following is a quotation of the appropriate paragraph of 35 U.S.C. § 102 that forms the basis for the following rejections:

> A person shall be entitled to a patent unless —
>
> (b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of the application for patent in the United States.

Claims 8, 27, 29, 31, and 35 are rejected under 35 U.S.C. § 102(b) as being anticipated by *The ARRL Handbook for Radio Amateurs 1993* ("the ARRL Handbook").

Figure 57 of the ARRL Handbook (Page 31-25) is reproduced below:

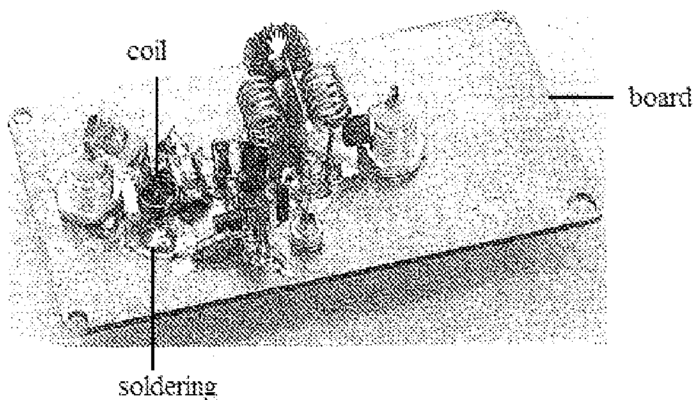

Figure 57 depicts a preamplifier with a coil and other circuit elements mounted on a board.

As shown above, the ARRL Handbook discloses a coil assembly comprising a coil (see coil reference line) having a coil opening defining an axis therethrough and an electric circuit board (see board reference line) wherein at least a surface portion is positioned against the coil in a substantially perpendicular relationship to the axis (The ARRL Handbook, 25; Fig. 57). While Figure 57 does not state the board is an electric circuit board, the plate clearly functions as part of the circuit to connect the electrical components shown into an integrated preamplifier. Thus, giving the term, "electric circuit board," its broadest reasonable interpretation, the board shown in Figure 57 is an electric circuit board.

Additionally, we note that Figure 57 shows a preamplifier, and claim 8 recites "a coil assembly for an electroacoustic transducer." The phrase, "for an electroacoustic transducer," is language relating to the function or intended use of the coil assembly. As courts have stated, "the absence of a disclosure relating to function does not defeat the Board's finding of anticipation. It is well settled that the recitation of a new intended use for an old product does not make a claim to that old product patentable." *In re Schreiber*, 128 F.3d 1473, 1477 (Fed. Cir. 1997). Thus, while Figure 57 and its description do not disclose the coil assembly being used in an electro-acoustic transducer, the disclosed assembly of Figure 57 is nonetheless capable of functioning as a coil assembly for an electro-acoustic transducer if it were so employed. Moreover, the coil assembly in Figure 57, as discussed above, includes all the recited structural limitations of claim 8. We, therefore, find that the coil assembly in Figure 57 of the ARRL Handbook anticipates claim 8.

Regarding claims 27 and 35, Figure 57 shows a surface portion of the electric circuit board is positioned against the coil by adhesion or soldering (see soldering reference line).

Regarding claims 29 and 31, both include the additional limitation of the electric circuit board having electronics for signal processing. As the device in Figure 57 is a preamplifier, there are ample electrical components that perform signal processing, including an output filter (the ARRL Handbook, 26). Thus, Figure 57 of the ARRL Handbook meets the limitations of the "electric circuit board includes electronics for signal processing" recited in claim 29 and the "electric circuit board including signal processing electronics" recited in claim 31.

Although we decline to reject every claim under our discretionary authority under 37 C.F.R. § 41.50(b), we emphasize that our decision does not mean the remaining claims are patentable over the ARRL Handbook. Rather, we merely leave the patentability determination of these claims to the Examiner. *See* MPEP § 1213.02.

DECISION

We have sustained the Examiner's rejections with respect to claims 8-11, 29-34 and 36. We have not, however, sustained the Examiner's rejections of claims 27, 28, and 35. Therefore, the Examiner's decision rejecting claims 8-11 and 27-36 is affirmed-in-part. We have, however, entered a new ground of rejection under 37 C.F.R. § 41.50(b) for claims 8, 27, 29, 31, and 35.

This decision contains a new ground of rejection pursuant to 37 C.F.R. § 41.50(b). Section 41.50(b) provides that "[a] new ground of rejection . . . shall not be considered final for judicial review."

This section also provides that the Appellants, WITHIN TWO MONTHS FROM THE DATE OF THE DECISION, must exercise one of the following two options with respect to the new ground of rejection to avoid termination of the appeal as to the rejected claims:

> (1) *Reopen prosecution.* Submit an appropriate amendment of the claims so rejected or new evidence relating to the claims so rejected, or both, and have the matter reconsidered by the examiner, in which event the proceeding will be remanded to the examiner. . . .

> (2) *Request rehearing.* Request that the proceeding be reheard under § 41.52 by the Board upon the same record. . . .

No time period for taking any subsequent action in connection with this appeal may be extended under 37 C.F.R. § 1.136(a)(1)(iv).

<u>AFFIRMED-IN-PART</u>
<u>37 C.F.R. § 41.50(b)</u>

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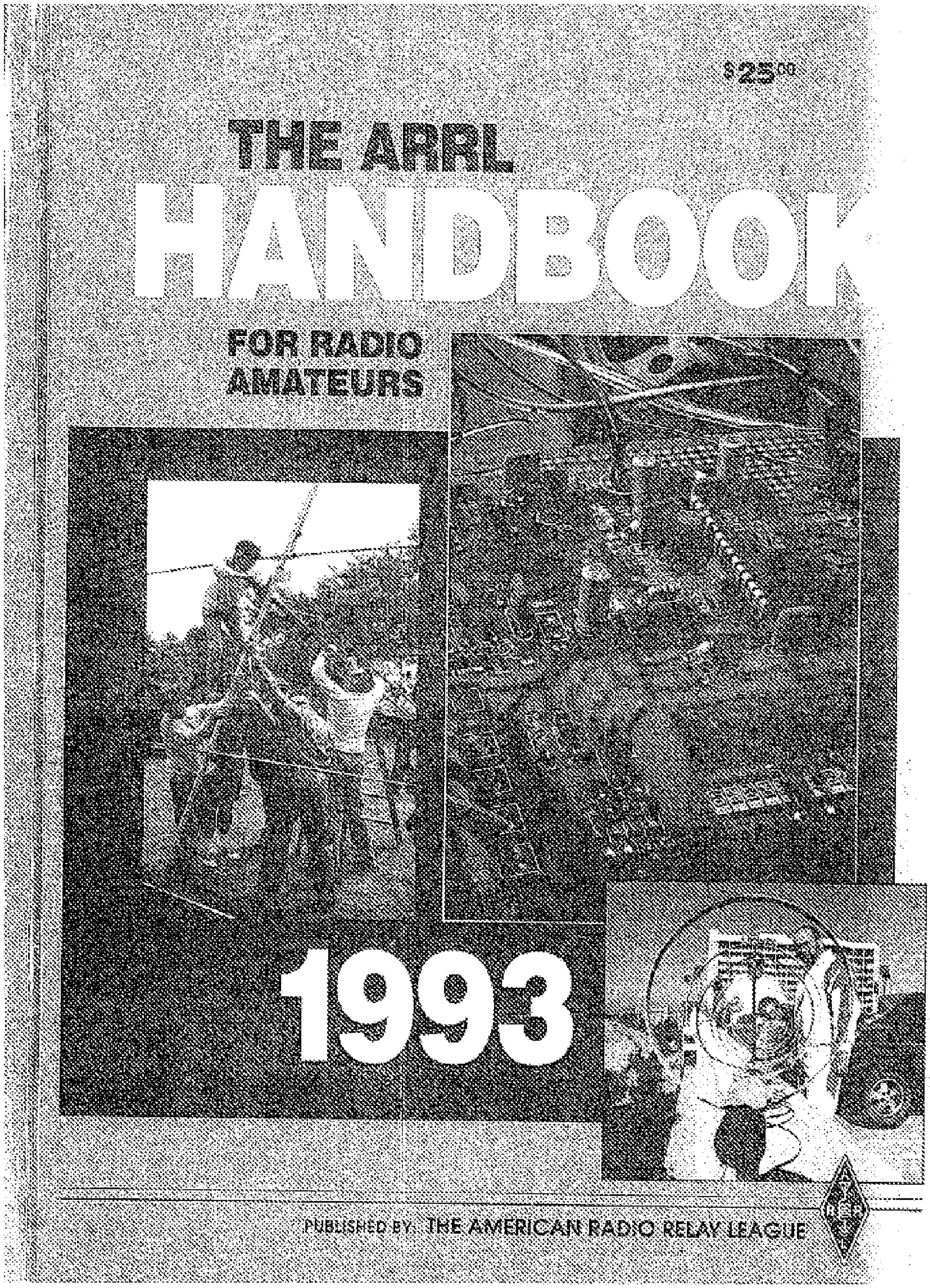
NIXON PEABODY, L.L.P.
161 N. CLARK STREET
48TH FLOOR
CHICAGO, IL 60601-3213

EVIDENCE APPENDIX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THE ARRL HANDBOOK FOR RADIO AMATEURS 1993

Seventieth Edition

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(A)

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(C)

Cover photos

A -- At the W3OK Field Day site in eastern Pennsylvania, N2LAU fastens the beam to a mast with the help of many friends. *(photo by N3GWR)*

B -- The ChipTalker project is new to this year's *Handbook*. Look for this voice memory keyer in the Digital Equipment chapter.

C -- Here's a view down the barrel of a 1296-MHz loop Yagi antenna. (Don't do this with a transmitter connected!) In the background is the site of the 1992 West Coast VHF/UHF Conference and the Pacific Ocean. *(photo by Gary Jue, N6QOA)*

Editor
Robert Schetgen, KU7G

Assistant Editors
Gerald L. Hall, K1TD
Joel P. Kleinman, N1BKE
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Deborah Strzeszkowski
Joe Shea
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Steffie Nelson, KA1IFB
Jodi Morin, KA1JPA
Sue Fagan, Cover
Michelle Bloom, WB1ENT

Contributors
Doug Bainbridge, N0HPK
John Belrose, VE2CV
Bert Beyt, W5ZR
Dennis Bodson, W4PWF
Bill de Carle, VE2IQ
Warren Dion, N1BBH
Martin Emmerson, G3OQD
Bill English, N6TIW
Ed Hare, KA1CV
Dick Jansson, WD4FAB
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William E. Sabin, W0IYH
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Linear Transverters for 144 and 220 MHz

The CW and SSB portions of the 144- and 220-MHz bands have swelled with activity during the past few years. Although there is plenty of commercially made CW and SSB gear for 144 MHz, there is little available for 220. Paul Drexler, WB2YYO, designed and built the linear transverters described here and shown in Figs. 40 through 62. These projects enable the use of a standard 28-MHz transceiver as a stable IF for 144- or 220-MHz operation. Construction is less complicated than building a complete transceiver, and all of the good features of the HF rig (such as a clean SSB source, stable VFO and good crystal filters) are incorporated. Chapters 11 and 12 contain additional information on transverter theory. Although these transverters may be tuned for any segment of operation, they were designed mainly to cover the lower portion of each band (144 to 148 MHz and 220 to 221 MHz). A 12-V power supply and an antenna are the only other equipment necessary to complete the VHF station.

The complete transverter design includes a minimum of hard-to-find components and should be easily reproducible. Although the text and illustrations center around the 220-MHz transverter, component values are given for the 144-MHz unit as well. Except for the local oscillator (LO), circuits are common to both designs. The receive converter has a 0.6-dB noise figure and an overall conversion gain of dB. These figures were verified on an 8970A noise-figure meter with an 346A noise source. Transmit-converter power output is a conservative 1 W under linear operation. The companion amplifier produces 8 to 10 W of linear output power. Much care was taken to make the transmit chain as clean as possible, and the receive converter incorporates techniques to maximize sensitivity and dynamic range.

CIRCUIT DESCRIPTION

Fig. 41 shows the transverter block diagram. The main difference between the 144- and 220-MHz versions is the LO. Although transceive operation is depicted, the experimenter may choose to limit construction to either transmit only or receive only. LO energy is injected into a high-level (+17 dBm) doubly balanced mixer during receive. Received signals are amplified by a GaAsFET preamplifier and then filtered before entering the mixer. The 28-MHz

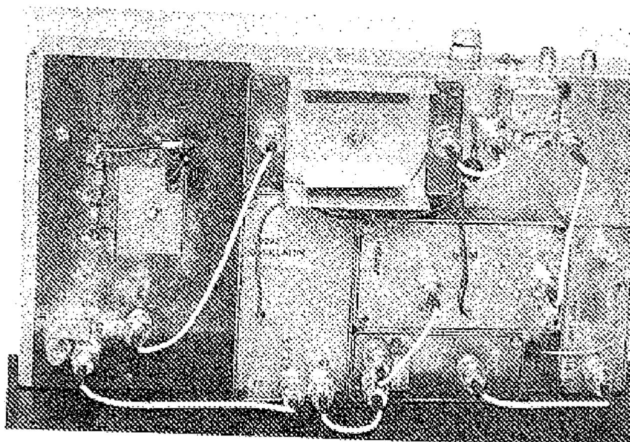


Fig. 40 — The 144- or 220-MHz transverter is built using a modular circuit approach. Each circuit is boxed and mounted on a chassis with interconnections of short lengths of 50-ohm coaxial cable.

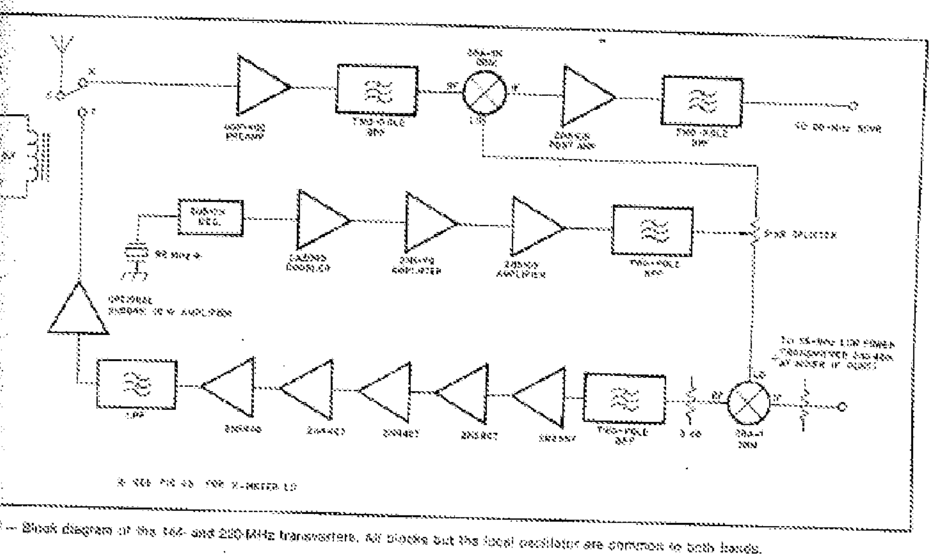


Fig. 41 — Block diagram of the 144- and 220-MHz transverters. All blocks but the local oscillator are common to both bands.

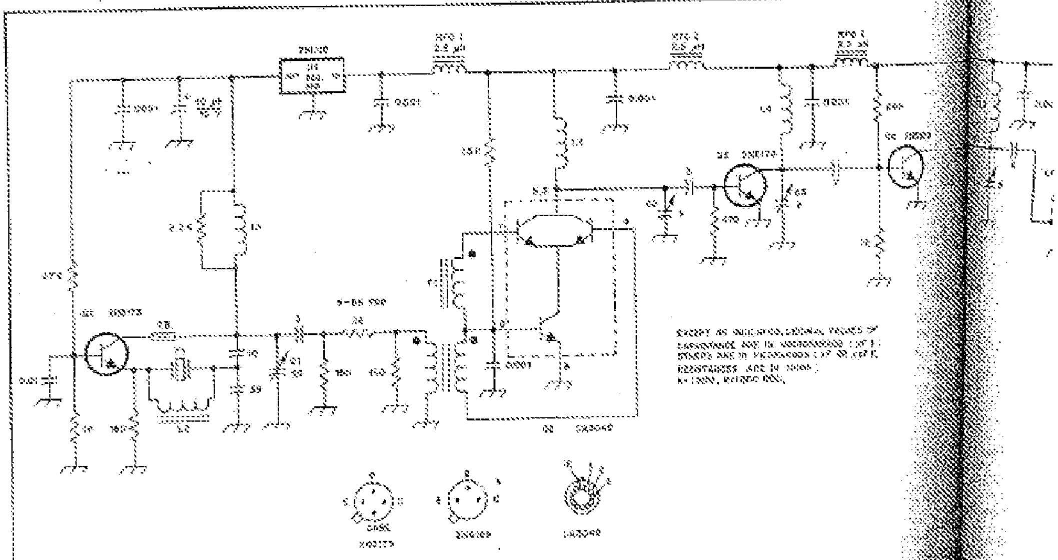


Fig. 42 — Schematic diagram of the 192-MHz local oscillator. All resistors are ¼-W carbon-composition types unless otherwise noted. Capac[illegible] are silver-mica or miniature monolithic ceramic types unless otherwise noted. Capacitors marked with polarity are electrolytic.

C1 — 25 pF (max.) miniature ceramic trimmer.
C2, C3, C4 — 5-pF (max.) miniature ceramic trimmer.
C5, C7 — 10-pF (max.) ceramic piston trimmer or miniature ceramic trimmer.
C6 — 0.5-pF ceramic chip or gimmick capacitor. See text.

J1, J2 — Chassis-mount female BNC connector.
L1 — 5½ t no. 24 enam., 0.100-inch ID, close wound.
L2 — 15 t no. 26 enam. on T25-6 toroid core.
L3, L4 — 3 t no. 24 enam., 0.125-inch ID, close wound.

L5 — 4 t no. 24 enam., 0.125-inch ID, clo[illegible] wound.
L6, L7 — 5 t no. 18 tinned, 0.25-inch [illegible] spaced one wire dia. Tap at 1 t from [illegible]
Q2 — RCA CA3049 transistor array. CA[illegible] Motorola MC3346 are acceptable subst[illegible]
RFC1-RFC4 — 2.2-µH molded miniature [illegible]

signal at the output port of the mixer is sent to a post amplifier and band-pass filter, and then to the 28-MHz IF receiver.

On transmit, LO energy and a low-level RF signal from the 28-MHz IF transceiver are fed to a standard-level (+7 dBm) doubly balanced mixer. The mixer output is filtered to eliminate the image and other unwanted responses, and then the desired signal is amplified by five stages to reach the 1-W level. The output of the 1-W transmit converter is further filtered to meet FCC rules and regulations. An optional 8- to 10-W amplifier is described for those desiring greater power output.

This transverter is built in a modular fashion. All of the major circuit blocks are built into separate enclosures and interconnected by 50-ohm coaxial cable. Modular construction lends itself to on-the-air experimentation and development, as well as simple troubleshooting. Any stage may be removed from the circuit for modification, or a new stage may be substituted. Although commercially available diecast boxes (BUD CU-123 and CU-124 or Hammond 1590A and 1590B) are used here, double-sided PC-board enclosures or Miniboxes may be used. Mounting all circuits in individual boxes is highly recommended for versatility and shielding. All component connections are made using direct, point-to-point construction techniques.

Local Oscillator

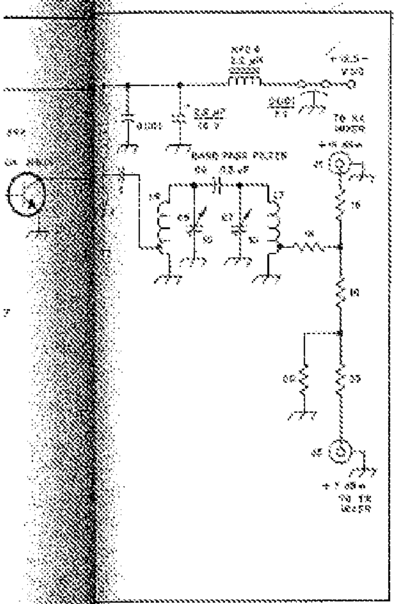
A schematic diagram of the local oscillator for the 220-MHz transverter is shown in Fig. 42. A frequency of 96 MHz has been chosen so that only one stage of multiplication is necessary to obtain the needed 192-MHz LO frequency. The crystal, Y1, is a series-resonant, fifth-overtone type in an HC-18/U package. The oscillator used is a common-base circuit derived from an article by Joe Reisert, W1JR.[4] Most crystal oscillators tend to oscillate at a frequency slightly higher than the crystal's fundamental mode of operation. In this circuit, L2 cancels the C_p crystal capacitance, thus bringing the oscillator down to the desired frequency.

The author chose to use a 95.95-MHz crystal (for a 191.9-MHz LO); an IF frequency of 28.1 MHz correspon[illegible] operating frequency of 220.0 MH[illegible] signals from stations operating [illegible] meters may be picked up by the [illegible] interconnecting cables, interfering [illegible] signals being received from 220 M[illegible] when more than one transverter [illegible] 28-MHz IF is operated in the sa[illegible] (at a multioperator VHF contest [illegible] for example), it is not uncommon [illegible] signals from the other IF trans[illegible]

Oscillator output is fed into [illegible] doubler constructed with a CA[illegible] sistor array. This circuit is based [illegible] gestion by Bill Sturck, K[illegible] doubler features as much as [illegible] excellent harmonic suppression [illegible] its balanced input circuit. A [illegible] MC3346 transistor array may [illegible] place of the CA3049.

Output energy from the [illegible] further amplified by Q3 and Q4 [illegible] the LO to the required mixer [illegible] Filtering is accomplished at th[illegible] by a lightly coupled double-tuned [illegible] spurious and harmonic energy [illegible] 55 dB below the desired signal [illegible] is necessary to avoid interference [illegible] caused by undesired mixin[illegible]

[4] Reisert, Joe, "VHF/UHF Receivers," Ham Radio, March 1984, pp. 42-48.



...ores.
...—7 t. no. 30 enam., trifilar wound on T25-12 ...ore or Mini-Circuits T4-1 transformer. See ...ext.
...—Three-terminal voltage regulator, 8 V, ...0 mA (LM78L08 or equiv.).
...—Fifth-overtone, 96-MHz series-resonant ...rystal, HC-18/U holder.

...ing receive and transmit.

...fter the filter, a resistive power divider ...sed to drive the transmit and receive ...ers. Resistive pads attenuate the LO ...al to the proper level while providing ...-Ω impedance for the mixer input.

...lthough a similar lineup could be ...ployed for 144 MHz, a three-stage ...-MHz oscillator is shown schematically ...Fig. 43. The 144-MHz transverter uses ...116-MHz series-resonant crystal (Y1) to ...al frequency multipliers. Oscillator out... is amplified by Q2 and Q3 until it ...ches the level necessary to drive both the ...smit and receive mixers. LO output is ...red by a double-tuned band-pass filter. ...fter the filter, a resistive power divider is ...d to drive the transmit and receive ...ers; again, pads attenuate the signal to ...proper level.

...ith the filters properly adjusted, all ...rious outputs from the LO are about ...dB below the fundamental. Fig. 44 ...ws the spectral output from the LO ...ive port.

...ive Converter

...e 144- and 220-MHz receive con... ...ers are identical, except for the tuned circuits in the front end. In each case, the converter consists of a GaAsFET preamplifier, a mixer/diplexer circuit and an optional 28-MHz post amplifier. The mixer/diplexer and post amplifier circuits are the same, regardless of band. Each of the three receive converter blocks is built into a separate module. This was done to facilitate experimentation and development of each stage. Of course, it is possible to build all three circuits in one box. This subject will be addressed in the construction portion of this article.

Mixer

The heart of the receive converter is a Mini-Circuits SRA-1H high-level, doubly balanced mixer (DBM). See Fig. 45. This mixer requires an LO injection level of +17 dBm, compared with the +7 dBm injection level required for standard mixers. The high-level mixer offers superior strong-signal handling characteristics while maintaining the port-to-port isolation, image suppression and simplicity inherent in a DBM. The SRA-1H is modestly priced and available in small quantities directly from the manufacturer.

Reactive terminations can ruin the excellent IMD characteristics of a DBM.[5,6] The IF port, in particular, is most sensitive to a nonresistive 50-ohm termination. Anything short of a 20-dB resistive pad at the IF port will result in increased IMD products and a lower third-order-intercept point. Feeding the output of a DBM directly into a narrowband amplifier will decrease the mixer's third-order intercept point as compared to a purely resistive termination. The diplexer circuit shown in Fig. 45 represents one solution to the problem of proper mixer termination. The diplexer's low-pass response presents a 20-dB return loss at 28 MHz and terminates higher frequencies into 50 ohms.

RF Preamplifier

A low-noise, high-dynamic-range GaAsFET preamplifier is used in front of the mixer to overcome mixer conversion loss. The GaAsFET device offers exceptional performance, compared with most bipolars and MOSFETs, and designs abound.[7,8] The circuit in Fig. 46 has proven reliable during many hours of on-the-air operation. This simple design offers a noise figure of 0.4 dB, as measured on an HP8970A noise-figure meter with the HP346A noise source. This noise figure is much lower than the feed line loss preceding the preamplifier; performance is exceptional for all applications short of intensive EME receiving. A 30-mA bias current achieves optimum signal-handling capability. The third-order-intercept point is +25 dBm. Gain is 24 dB.

The double-tuned filter between the preamp and mixer provides a reasonable degree of filtering. A trap (L2) is used to attenuate the 164-MHz (188 MHz for the 2-meter version) image. Fig. 47A shows the swept frequency response of the 220-MHz version. A comb line or helical filter might be used if greater selectivity is required.

28-MHz Post Amplifier

For most amateur applications, a 28-MHz post amplifier is not necessary. It serves to amplify the 28-MHz IF signal to increase S-meter readings. The author lives among several of the "big gun" VHF stations in southeastern Pennsylvania, so high dynamic range is essential to avoid overload problems. The receive converter operates nicely without any post amplification, thereby preserving the IF receiver's dynamic range.

The 28-MHz post amplifier shown in Fig. 48 has been included here for those operators fortunate enough to live away from strong in-band signals. The 2N5109 is readily available and provides good performance at low cost. In this circuit, the device is biased to provide 13-dB gain with a third-order-intercept point of +26 dBm. The design features a tuned input circuit and a broadband output transformer. A double-tuned band-pass filter at the output assures a clean signal for the IF receiver. Fig. 47B shows the swept frequency response of the post amplifier.

If you live in an area with loud local signals, yet want to use a post amplifier, a pad may be used between the post amplifier and the IF receiver to reduce the converter gain to a level that the IF receiver can handle. The value of attenuation will depend on the IF receiver's ability to handle large signals. When you first connect the receive converter to the IF receiver, you will probably notice that the S-meter on the receiver moves up to S3 or higher (a lot depends on the nature of your specific receiver), even with no signals present. To determine the right pad value for your application, place a variable step attenuator in the line between post amp and IF receiver and increase the attenuation until the IF receiver S-meter is just above zero. If you want to leave the step attenuator in the line, fine. If not, you can build a pad with the correct value from the attenuator tables given in Chapter 25 of this *Handbook*.

Transmit Converter

A schematic diagram for the 1-W transmit converter is shown in Fig. 49. The 192-MHz LO (116-MHz LO for the 144-MHz version) and 28-MHz signals are mixed in a Mini-Circuits SRA-1 standard-level DBM. A pad is necessary to limit the 28-MHz input to a maximum level of −10 dBm, ensuring good linearity and

[5]Will, Peter, "Reactive Loads — The Big Mixer Menace," *Microwaves*, April 1971, pp. 38-42.
[6]Cheadle, Dan, "Selecting Mixers for Best Intermod Performance," *Microwaves*, Nov. and Dec. 1973.
[7]Kraus, Geoff, "VHF and UHF Low Noise Preamplifiers," *QEX*, Dec. 1981, p. 3.
[8]Reisert, Joe, "Low Noise GaAsFET Technology," *Ham Radio*, Dec. 1984, pp. 99-112.

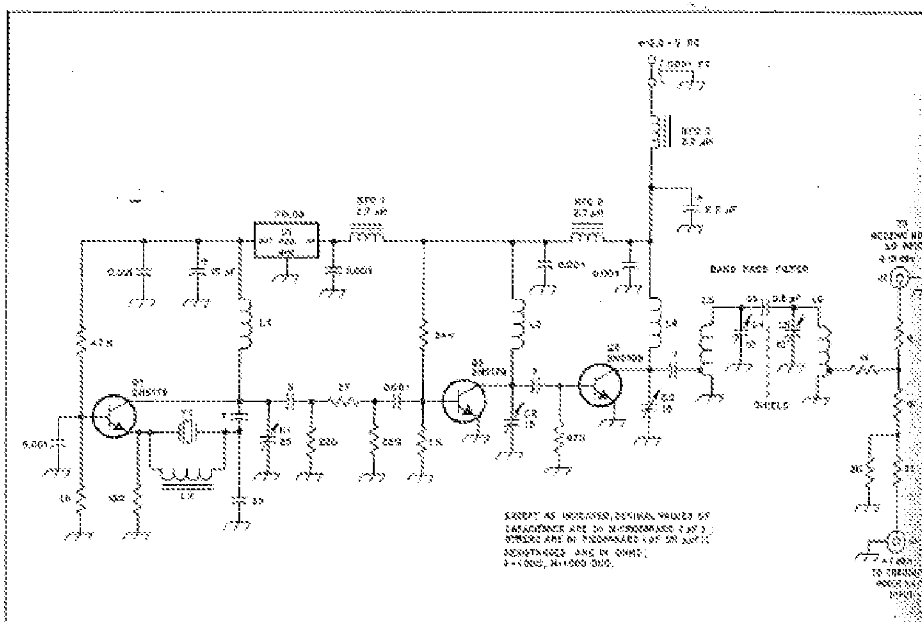


Fig. 43 — Schematic diagram of the 116-MHz local oscillator for the 2-meter transverter. All resistors are ¼-W, carbon-composition types unless otherwise noted. Capacitors are silver-mica or miniature monolithic ceramic types unless otherwise noted. Capacitors marked with polarity are electrolytic.

C1 — 25-pF (max.) miniature ceramic trimmer.
C2, C3 — 15-pF (max.) miniature ceramic trimmer.
C4, C5 — 15-pF (max.) ceramic piston trimmer or miniature ceramic trimmer.
C6 — 0.5-pF ceramic chip or gimmick capacitor. See text.
J1, J2 — Chassis-mount female BNC connector.
L1 — 3t no. 24 enam., 0.150-inch ID, close wound.
L2 — 13t no. 28 enam. on T25-6 toroid core.
L3, L4 — 7t no. 24 enam., 0.125-inch ID, close wound.
L5, L6 — 3t no. 18 tinned, 0.250-inch ID, spaced one wire dia. Tap at 1t from [illegible]
RFC1-RFC3 — 2.7-µH molded miniature choke.
U1 — Three-terminal voltage regulator, [illegible] 100 mA (LM78L08 or equiv.).
Y1 — Fifth-overtone, 116-MHz series-mode crystal, HC-18/U holder.

spectral purity. No parts values are shown for the IF pad; the exact resistor values will depend on the amount of 28-MHz drive available from the transverter output of your IF transceiver. For example, if your IF rig delivers 20 mW (+13 dBm) at the transverter output, you would need to build a 23-dB pad. See Chapter 25 for tables listing resistor values for different levels of attenuation.

Mixer output is fed through a resistive pad for proper termination, and then filtered by a double-tuned band-pass filter to reduce the image and other undesired mixing products. Two 2N2857 amplifier stages follow the filter, followed by two 2N4427 stages. The final amplifier stage is a 2N5946. All stages are biased for linear operation. The 2N5946 may be substituted with a lower-power 2N5945 or 2N5944 device; if you substitute, you may have to alter the input and output matching, as well as the bias circuit. A 7-element Chebyshev low-pass filter (Fig. 50) follows the 2N5946. Swept filter response is shown in Fig. 51B. The output is exceptionally clean; a spectral plot is shown in Fig. 51A.

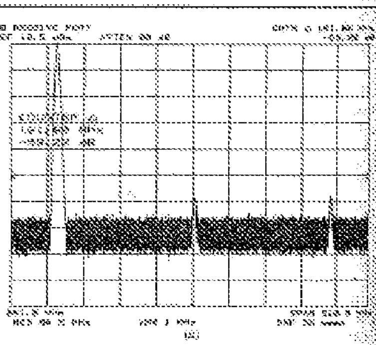
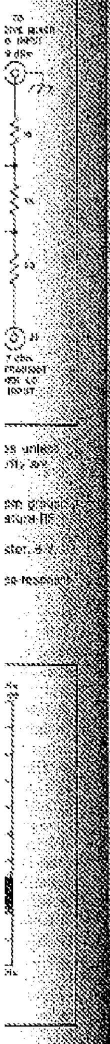


Fig. 44 — Spectral output of the 132-MHz LO receive port. All harmonic and spurious outputs are at least 58 dB below peak fundamental output.

Although some designers may question the use of five stages to achieve 1-watt output, there are several good reasons for doing so. This transmit converter is rated for conservative operation at [illegible] filtered 1-W output. It is not [illegible] watt, like some four-stage designs [illegible] stages are run below their maximum [illegible] ble output level, ensuring clean [illegible]



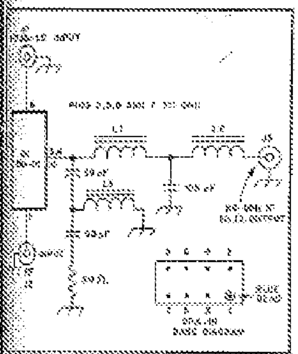


Fig. 45 — Schematic diagram of the receive mixer and diplexer filter. Capacitors are silver-mica. Resistors are ¼-W carbon-composition types.

J3 — Chassis-mount female BNC connector.
L1 — 0.35 µH; 8t no. 24 enam. on T50-6 toroid core.
L2 — 0.208 µH; 8t no. 24 enam. on T50-6 toroid core.
L3 — 0.18 µH; 8t no. 24 enam. on T37-6 toroid core.
U1 — Mini-Circuits SRA-1H high-level, doubly balanced mixer. Available directly from the manufacturer. See text.

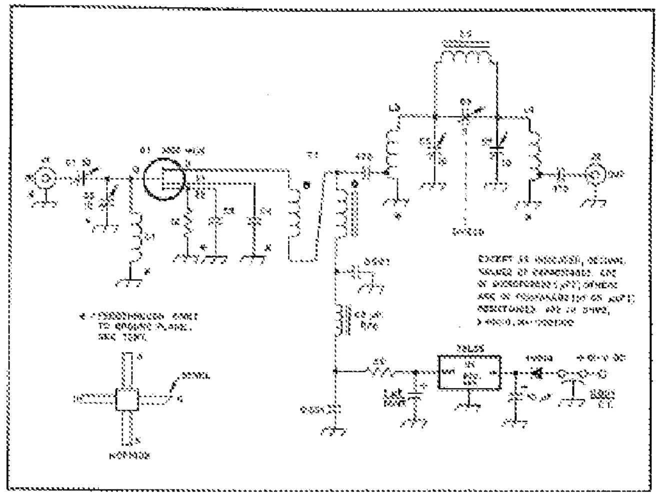


Fig. 46 — Schematic diagram of the 144- or 220-MHz GaAsFET preamplifier. All resistors are ¼-W carbon composition types unless otherwise noted. Capacitors are silver-mica or miniature monolithic ceramic types unless otherwise noted. Capacitors marked with polarity are electrolytic.

C1, C2, C5, C7 — 10-pF (max.) ceramic piston trimmer or miniature ceramic trimmer.
C3, C4 — 500-pF ceramic chip capacitor.
C6 — 0.3 to 3 pF ceramic piston trimmer.
J1, J2 — Chassis-mount female BNC connector.
L1 — 220 MHz: 3t no. 18 enam., 0.250-inch ID, close wound. 144 MHz: 5t.
L2 — 220 MHz: 13t no. 24 enam. on T44-10 toroid core; 144 MHz: 27t no. 28 enam. on T37-10 toroid core.
L3, L4 — 220 MHz: 5t no. 18 tinned wire, 0.250-inch ID, spaced one wire dia. Tap at 1t from ground. 144 MHz: same as 220 MHz, except coil is 7t.
Q1 — Single-gate GaAsFET, MGF1402.
RFC1 — 68-µH molded miniature RF choke.
T1 — 4t no. 28 enam. bifilar wound on T25-12 toroid core.
U1 — Three-terminal voltage regulator, 5 V, 100 mA (LM78L05 or equiv.).

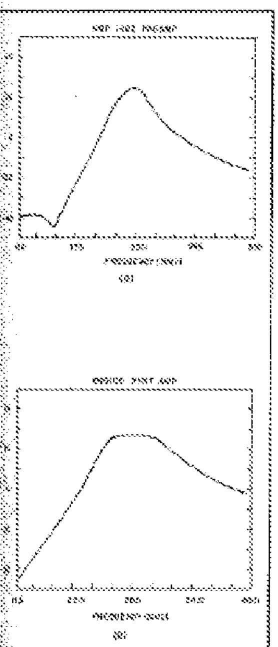


Fig. 47 — Swept response of the 220-MHz preamplifier (A) and the 28-MHz post amplifier (B). The image filter at the output of the 220-MHz preamplifier produces a deep null at 192 MHz.

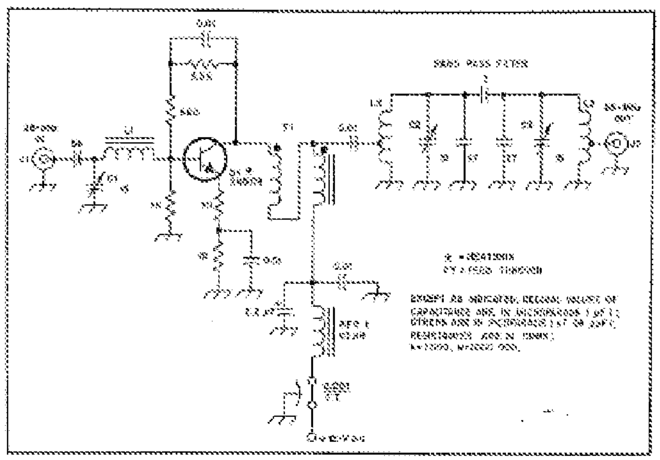


Fig. 48 — Schematic diagram of the 28-MHz post amplifier. All resistors are ¼-W carbon-composition types unless otherwise noted. Capacitors are silver-mica or miniature monolithic ceramic types unless otherwise noted. Capacitors marked with polarity are electrolytic.

C1, C2, C3 — 15-pF (max.) miniature ceramic trimmer.
J1, J2 — Chassis-mount female BNC connector.
L1 — 12t no. 26 enam. on T37-6 toroid core.
L2, L3 — 15t no. 26 enam. on T37-6 toroid core. Tap at 4t from ground.
RFC1 — 10-µH miniature molded RF choke.
T1 — 20t no. 30 enam. bifilar wound on T37-10 toroid core.

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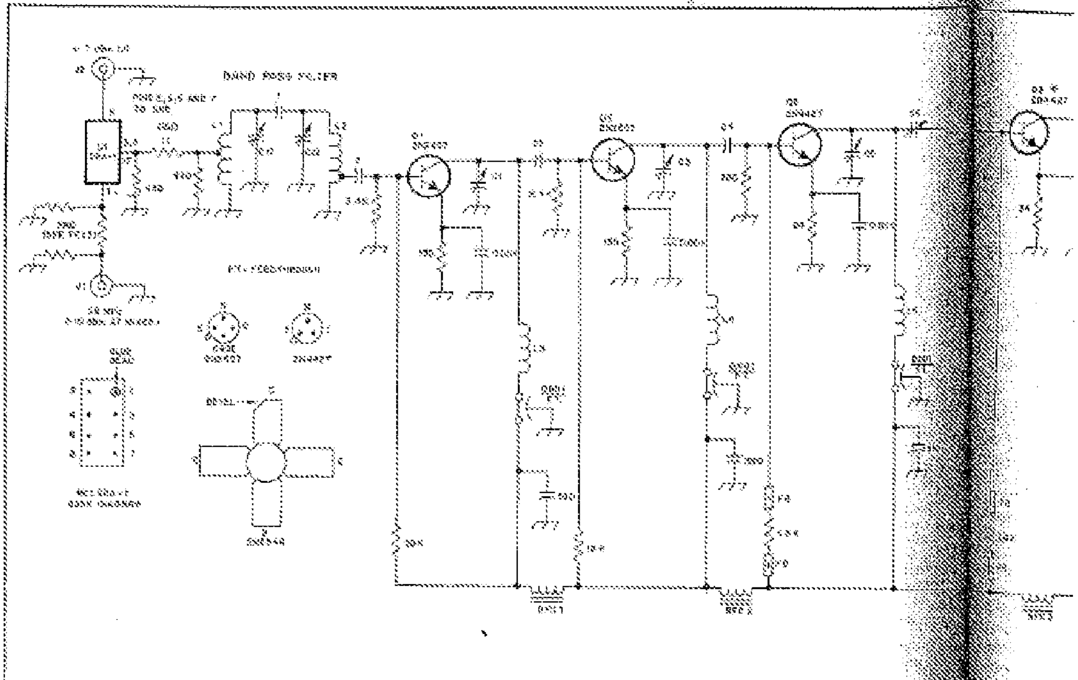

Fig. 49 — Schematic diagram of the 144- and 220-MHz transmit converter. All resistors are ¼-W carbon-composition types unless otherwise noted. Capacitors are silver-mica or miniature monolithic ceramic types unless otherwise noted. Capacitors marked with polarity are electrolytic.

C1, C3, C5, C6, C7 — Miniature ceramic trimmer, 220 MHz: 8 pF (max.); 144 MHz: 25 pF (max.).
C2 — Silver-mica capacitor, 220 MHz: 2 pF; 144 MHz: 3 pF.
C4 — Silver-mica capacitor, 220 MHz: 3 pF; 144 MHz: 5 pF.
C8 — Miniature ceramic trimmer, 220 MHz: 15 pF (max.); 144 MHz: 25 pF (max.).
C9, C10 — 25-pF (max.) miniature ceramic trimmer (same for both bands).
C11, C12 — Ceramic piston trimmer or miniature ceramic trimmer, 220 MHz: 10 pF (max.); 144 MHz: 25 pF (max.).
J1-J3 — Chassis-mount female BNC connector.
L1, L2 — 220 MHz: 4t no. 20 tinned, 0.250-inch ID, spaced one wire dia. Tap at 1t from ground. 144 MHz: Same as 220 MHz except coil is 6t.
L3, L4, L5 — 220 MHz: 3t no. 20 tinned, 0.250-inch ID, spaced one wire dia. 144 MHz: Same as 220 MHz except coil is 5t.
L6 — 220 MHz: 1t no. 20 tinned, 0.250-inch

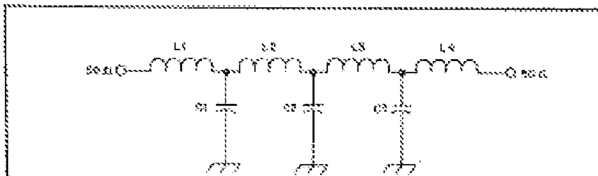

Fig. 50 — Schematic diagram of 7-element Chebyshev low-pass filter. Capacitors are silver-mica types.

C1, C3 — 220 MHz: 15 pF; 144 MHz: 27 pF.
C2 — 220 MHz: 18 pF; 144 MHz: 30 pF.
L1, L4 — 220 MHz: 3t no. 22 enam., 3/16-inch ID, close wound; 144 MHz: also 3t.
L2, L3 — 220 MHz: 4t no. 22 enam., 3/16-inch ID, close wound; 144 MHz: 5t.

operation. The gain from the extra stage also allows the use of the filters after the mixer and at the output. The author lives in an area where the VHF bands are congested, so clean, linear operation is a must for sound relations with other amateurs sharing the band.

Power Amplifier

An optional 8- to 10-W linear power amplifier is shown schematically in Fig. 52. This amplifier uses another 2N5946 transistor. The design is relatively simple. Input matching is accomplished by C1, C2 and L1. L2, C3 and C4 match the output. The only differences between the 220-MHz and 144-MHz versions are the values of L1 and L2.

The bias circuit, suggested by Dave Mascaro, WA3JUF, uses an LM317 adjustable regulator to provide a [illegible] supply. The LM317 circuit is capable of providing 30- to 40-mA of stable [illegible] current.

Switching

Fig. 53 is a schematic diagram [illegible] transverter switching circuitry. [illegible] to switch power to the transverter [illegible] in transmit and receive. When [illegible]

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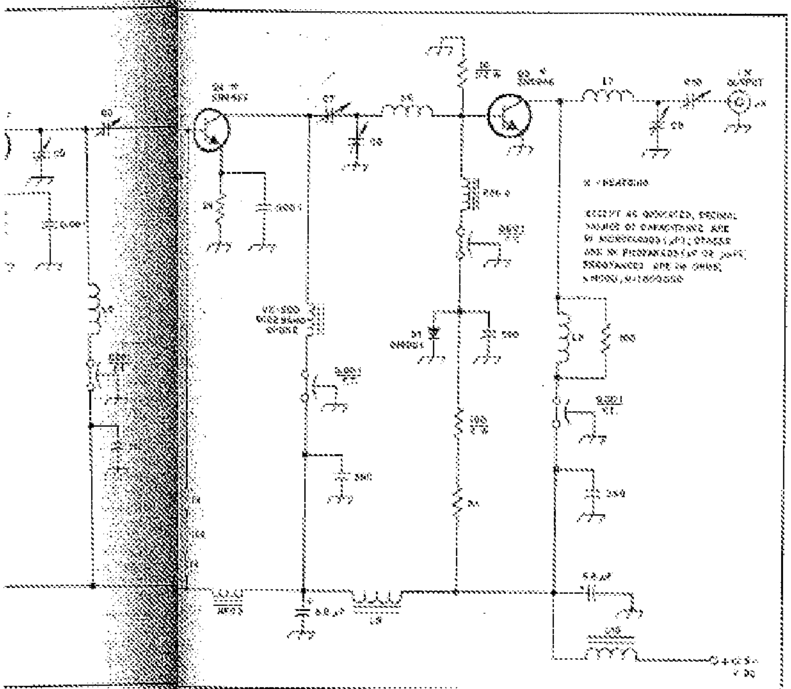


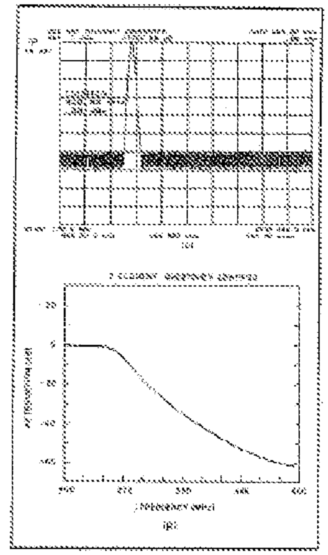


Fig. 51 — The plot at A shows the spectral output of the 1-W, 220-MHz transmit converter after filtering. All harmonics and spurious emissions are at least 60 dB below the fundamental output. This transmit converter meets current FCC spectral-purity specifications. The plot at B is the swept frequency response of the low-pass filter shown in Fig. 50.

unless otherwise noted ... are electrolytic.

... MHz: 2t no. 20 tinned, 0.250-inch ID, ... one wire dia.
... 220 MHz: 1t no. 20 tinned, 0.250-inch ID.
... MHz: 3t no. 20 tinned, 0.250-inch ID, ... one wire dia.
... 220 MHz: 5t no. 20 enam., 0.250-inch ID, ... wound. 144 MHz: Same as 220 MHz ... coil is 8t.
... — 15 t no. 22 enam. on T44-10 toroid core (same for both bands).

R1 — Start with 68-ohm, 2-W resistor; vary for proper bias. See text.

RFC1-RFC4 — 220 MHz: 1.8-µH miniature molded RF choke; 144 MHz: 2.2-µH miniature molded RFC.

U1 — Mini-Circuits SRA-1 standard level, doubly balanced mixer. Available directly from the manufacturer. See text.

... is powered on, 12.5-V dc is applied ... to the LO and through K1 to the ... preamplifier and 28-MHz post amplifier. When J2 is closed, K1 removes power ... the preamplifier and post amplifier ... applies 12.5-V dc to the transmit converter and power amplifier. The LO, used ... transmit and receive, is always on. ... J2 is closed, K2 is also energized. ... RF relay, switches the antenna between the VHF preamplifier input and the ... amplifier output. Relays of this type ... usually available at flea markets at ... prices. Since most HF transceivers ... separate transverter input and output ... connections, no relay switching for the IF ... included. The transmit converter IF ... connected directly to the transverter ... on the HF transceiver, while the ... amplifier output is connected directly ... transverter input on the HF ... receiver. ... with 26-V dc coils were used here since most surplus coaxial relays require this voltage. While relays with any coil voltage could be used, it is a good idea to run relays and electronics from separate power supplies to avoid possible problems caused by voltage transients that occur when the relay coils are switched. The diode and capacitor connected across the relay coil power line help to alleviate transients.

CONSTRUCTION TECHNIQUES

Although this project is not intended for a first-time effort, anyone having a reasonable amount of VHF construction experience should encounter no difficulty. As with all VHF circuits, a certain amount of construction care is required.

Proper grounding techniques, RF bypassing and shielding will ensure stable operation. Feedthrough grounding is used to provide a low-inductance ground return to both sides of the PC board. Basically, this means drilling a hole through the PC board at key points where components must have a good RF ground and installing a rivet or piece of no. 20 tinned wire soldered to both sides of the board. See Fig. 54. Check the schematic diagrams for each circuit and install ground feedthroughs accordingly.

High-quality, low-inductance capacitors ensure a good RF bypass. Ceramic chip capacitors work best. These can be expensive, however, so they are used only where absolutely necessary. Epoxy encapsulated, miniature, monolithic ceramic capacitors work quite well as bypass capacitors.

Tight shielding between the input and output of each stage of the transmit converter eliminates the likelihood of feedback. Shielding was only found necessary on the transmit converter.

The variable capacitors used in each stage are miniature ceramic or piston trimmers. The value of these capacitors is not critical as long as you use capacitors with maximum values close to those specified in the schematic diagram. For example, there are many capacitors available with a range from 2 to 8 pF or 2 to 12 pF. Any of these will work fine in circuits that call for 9- or 10-pF-maximum variables. Ceramic piston trimmers are most convenient for building the double-tuned band-pass filters. Johan-

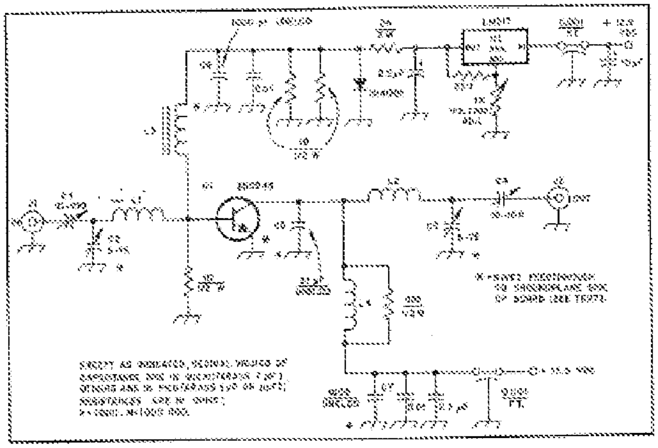


Fig. 52 — Schematic diagram of the 8- to 10-W power amplifier. Capacitors are monolithic ceramic types unless otherwise noted. Capacitors marked with polarity are electrolytic.

C1, C4 — 10-100 pF mica trimmer (Arco 406 or equiv.).
C2, C3 — 5-75 pF mica trimmer (Arco 405 or equiv.).
C5 — 51 pF metal-clad button-mica capacitor. See text.
C6, C7 — 1000 pF metal-clad button-mica capacitor. See text.
J1, J2 — Chassis-mount female BNC connector.
L1 — 220 MHz: 1¼ no. 20 tinned, 0.250-inch ID ("hairpin loop"); 144 MHz: 1¾ no. 20 tinned, 0.250-inch ID.
L2 — 220 MHz: 1½ no. 20 tinned, 0.250-inch ID; 144 MHz: 2½ no. 20 tinned, 0.250-inch ID, spaced one wire dia.
L3 — VK-200 wideband RF choke.
L4 — 8 no. 20 enam., 0.250-inch ID, close wound.
Q1 — 2N5946 or Thompson-CSF SD1190 RF power transistor.
U1 — Three-terminal adjustable voltage regulator, 1 A (LM317 or equiv.).

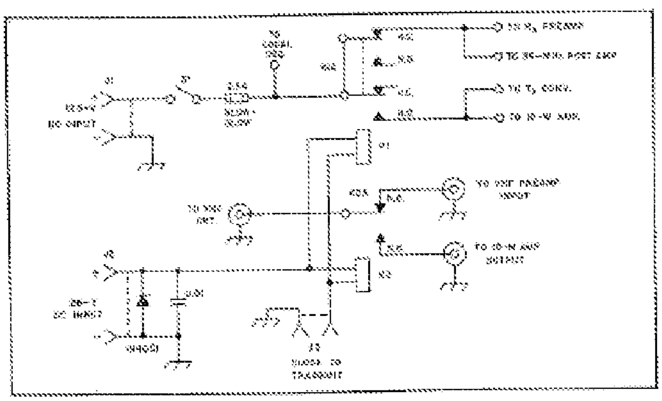


Fig. 53 — Schematic diagram of the transverter switching arrangement.

J1, J2 — Chassis-mount female Cinch-Jones power plug.
J3 — Chassis-mount phono jack.
K1 — DPDT power relay, 5-A contacts, 28-V dc coil.
K2 — SPDT coaxial antenna changeover relay, BNC connectors, 28-V dc coil.
S1 — SPST switch, 5-A contacts.

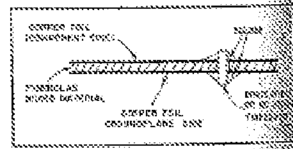


Fig. 54 — Detail of the feedthrough ... used to achieve a good RF ground. See ... for details.

son, Trimtronics or Voltronics all manufacture 8- to 10-pF maximum piston trimmers suitable for these filters.

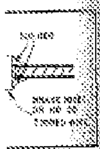
"Dead bug" layout is best suited for VHF/UHF construction. As shown in the accompanying photographs, components are supported by their leads above the ground plane. In most cases, component leads are soldered directly to the leads of other components, keeping the length of each interconnection to a minimum. A low-inductance RF ground is achieved since the component leads are soldered directly to the ground plane. This construction method eliminates the need for ... an etched PC board, a task not easily ... complished at VHF and above.

Each circuit, or "module," is built ... a piece of double-sided circuit board ... and mounted in a separate metal enclos... In the transverter shown in the ... graphs, each module is built into a small Hammond 1590 series diecast box. In ... case, the box cover has been discarded ... circuit board holding the components ... been shaped to fit the box tightly in pl... of the cover. Each module has BNC ... nectors for RF input and output ... is supplied through a feedthrough capaci... tor. The result is an RF-tight enclosure ... each part of the circuit. Since the ... transmit converter board is large, ... suitable diecast box is expensive ... transmit converter is mounted ... chassis that supports the rest of the modules.

Finding Parts

These days, it is becoming increasingly difficult to find parts. This trans... makes use of parts available from a ... of sources. The parts suppliers ... Chapter 35 lists many possible sources ... still others advertise in *QST* and ... amateur magazines. Some parts sources ... listed below. You can find address... other information in Chapter 35 for ... panies that are listed by name only ... This list is by no means complete ... sources that the author knows of ... sell to individuals in small quantities.

- •Advanced Receiver Research, Box 1242, Burlington, CT 06013 (MGF1402 GaAsFETs)
- •Amidon Associates (toroid cores, ferrite beads, VK-200 chokes)
- •Applied Invention (piston trimmers, chip caps)
- •MHz Electronics, 3802 N. 27th ..., Phoenix, AZ 85017 (transistors, ... mica capacitors)
- •Microwave Components of Michigan (trimmers, piston trimmers, GaAsFETs, chip caps, feedthrough caps, diecast boxes)
- •Mini-Circuits, P.O. Box 166, Brooklyn, NY 11235 (mixers, ... 192-MHz LO)
- •Mouser Electronics (resistors, ... capacitors, ceramic trimmers, ... RF chokes, diecast boxes)
- •Radiokit (toroid cores, ferrite beads, Arco variables, diecast boxes)



RF Gain, Ltd. (transistors)

Local Oscillator

Build the local oscillator first; you'll need its energy to test most of the other stages. Before soldering anything, gather all of the necessary components and lay them out on the board in order to plan adequate room for construction. Follow the schematic diagram and refer to Fig. 55 for an idea of how to lay out the board. Although the 192-MHz LO for the 220-MHz transverter is shown, layout is similar for the 116-MHz version.

Once the general layout scheme has been determined, the components may be soldered together, beginning with Q1. Keep component leads short, but leave enough room so that you can change components if necessary. Make sure that the leads of Y1 are as short as possible and that the crystal will not touch the box that the LO will be installed in. A dab of silicone sealant will hold the crystal in place.

Q1, Q2 and Q3 are mounted "belly up" with their leads sticking into the air. Note that Q1 and Q3 have a lead that is connected to the case. Solder this lead to ground. The collector of Q4 is tied to the case, so it is mounted with the leads facing the ground plane. Make sure that the case of Q4 does not touch the ground plane or other components.

The power for the LO enters the case through a feedthrough capacitor. Miniature molded RF chokes and bypass capacitors decouple the power line at each stage. In Fig. 55, these RFCs and capacitors are arranged in a horizontal line that traverses the top of the board. Q1 is powered through an 8-V, three-terminal regulator. Mount the associated bypass capacitors as close to the IC body as possible.

... has several unused sections. Cut off the unused leads before soldering it into the circuit. T1 is a trifilar-wound transformer on a T25-12 toroid core. See Fig. 56 for details. Although the transformer used here is wound by hand, a Mini-Circuits model ... may also be used.

The output filter uses two ceramic piston trimmer capacitors mounted through the circuit board. These piston trimmers make it convenient to mount L6 and L7; common ceramic trimmers like those used in the rest of the circuit will also work here. A shield made from a piece of double-sided circuit-board material separates L6 and L7, preventing overcoupling and ensuring a "clean" filter response. Although a 0.5-pF ceramic chip capacitor was used to couple the two filter sections, a ½-inch-long gimmick capacitor made from two pieces of ... enameled wire twisted tightly together will work here.

One of the advantages of dead bug construction — one that you should take advantage of — is that each stage can be tested individually. After you build the oscillator (Q1 and associated components), you can test for 96 (or 116) MHz

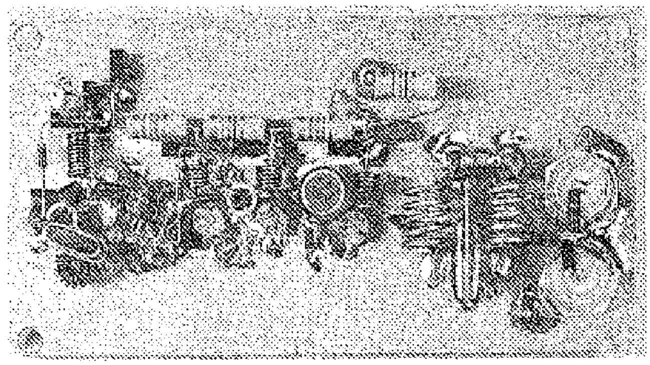


Fig. 55 — The 192-MHz local oscillator is laid out in the order it is drawn on the schematic diagram. Q1 is at the far left, Q4 is near the center of the board. The band-pass filter is at the right, next to J1 and J2. The resistors used for the power divider and pad are soldered into the circuit with virtually no lead length.

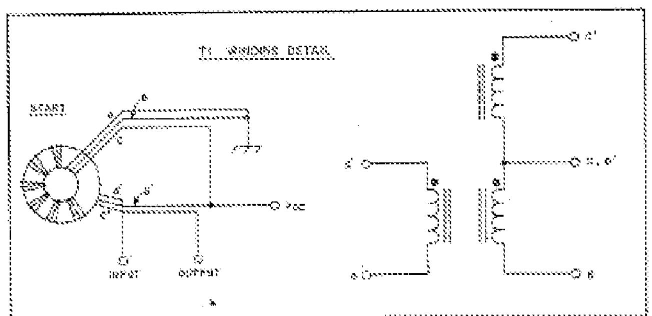


Fig. 56 — Winding details for T1 in the 192-MHz LO. Label one end of three 5-inch pieces of enameled wire as shown. Holding all three wires flat, in parallel, begin threading the toroid starting with the unlabeled end of the three wires. Carefully wind the toroid by feeding the entire group of wires in parallel. Once seven turns have been wound, use an ohmmeter to trace the unlabeled ends. Label the end of wire A by A', and so on. After the windings have been properly labeled, connect T1 as shown.

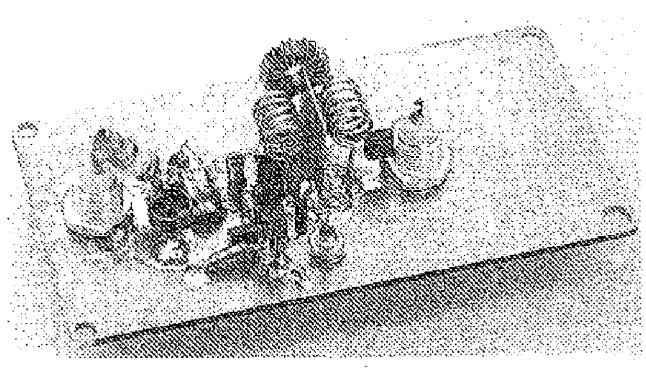


Fig. 57 — Closeup of the VHF RF preamplifier. The input components at the left of the board are mounted with as little lead length as possible, to minimize losses.

output by capacitively coupling into a receiver or spectrum analyzer from the 50-ohm pad at the output of the stage. When you are sure Q1 is working, build the next stage and test it. Proceed alternately building and testing each stage until you reach the final output stage.

When all of the LO stages are complete, check the operating frequency with a counter or spectrum analyzer. Tune each stage for maximum output. Tuning is somewhat interactive, so recheck each stage after you have done the initial tuneup. Each variable capacitor should have a definite peak. If you have a method of checking low power levels, check the output at the receive and transmit ports. Power output should be as indicated on the drawings.

All other stages are constructed in a like manner. Lay the board out in advance; start at the input and work toward the output. Test each stage after you build it, and fix any problems before continuing to the next stage.

Preamplifier

The GaAsFET transistor requires special handling care because it is especially sensitive to static electricity. Solder the transistor into the circuit last; use a grounded-tip, low-temperature soldering iron. If a static-free work station is unavailable, ground yourself before removing the MGF1402 from its protective package to prevent static buildup from destroying the device.

Although an MGF1402 is specified, you can use other devices if you change the biasing resistors accordingly. Consult the references listed at the end of this project writeup before attempting a substitution. The MGF1402 is a fairly common transistor and is available from several of the suppliers listed in Chapter 35.

The general layout is shown in Fig. 57. Although BNC connectors were used here, Type-N or SMA connectors may be employed. A number of ground feedthroughs are used at points indicated on the schematic diagram. These feedthroughs are necessary for stable operation and optimum performance; they must be used. See Fig. 54.

Ceramic chip capacitors are mandatory for the source bypass on the MGF1402. Do not attempt to substitute low-grade capacitors here! Chip capacitors provide a low-impedance source ground; this is of particular importance for stable operation with high-gain devices such as the microwave GaAsFET used here. The MGF1402 is mounted directly to the source bypass capacitors by its source leads. First, solder one end of each chip capacitor to the ground plane. Then solder one source lead to each chip capacitor. See the preamplifier projects that appear earlier in this chapter for complete details of this mounting scheme.

The output filter is similar to the one described in the local-oscillator section. In

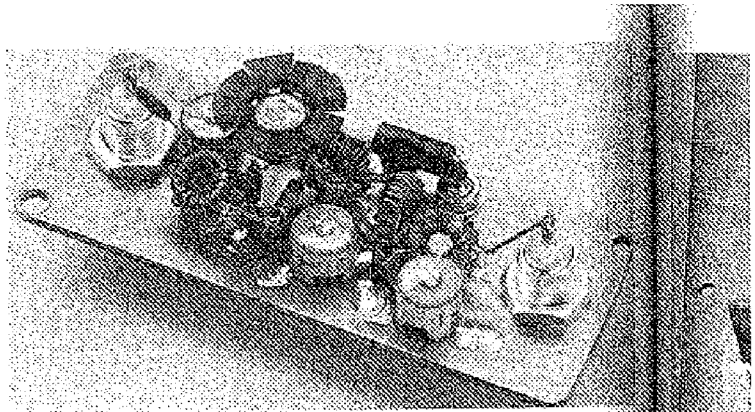


Fig. 58 — Closeup of the 28-MHz post amplifier. Q1 uses a push-on finned heat sink. The transistor case is tied to the collector, so the heat sink must be positioned away from the board and nearby components.

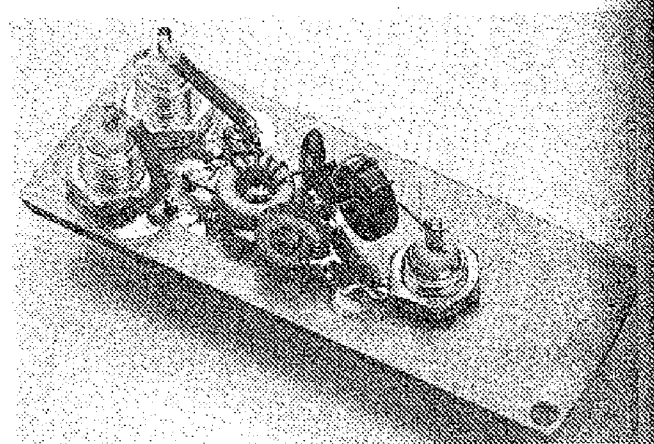


Fig. 59 — Closeup of the receive mixer and diplexer filter. RG-178 cable is used between the mixer and input connectors.

this case, however, the coupling capacitor is a 0.3- to 3-pF trimmer. A toroidal coil is added for the 164-MHz image trap.

28-MHz Post Amplifier

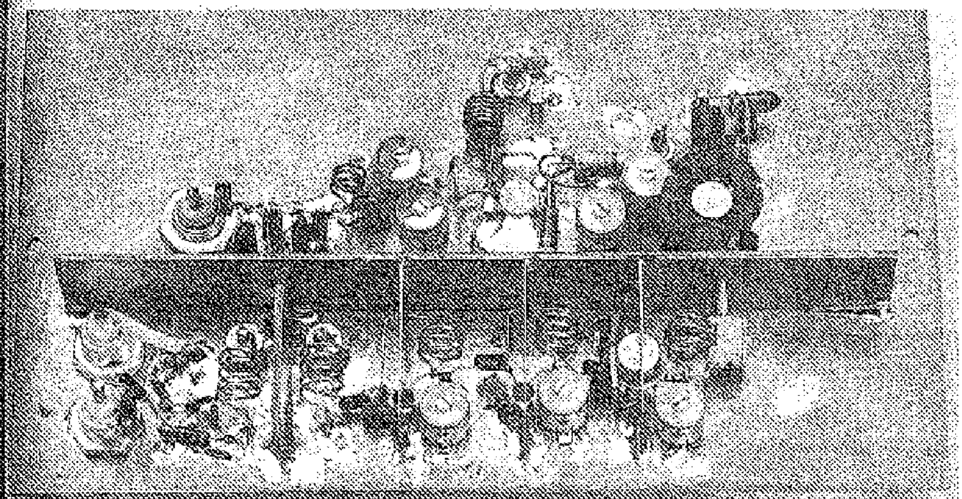
The 2N5109 post amplifier shown in Fig. 58 requires little special care. Note, however, the use of a push-on, finned heat sink. Keep the heat sink away from the circuit board and other components since the 2N5109 case is tied to the transistor collector.

Receive Mixer

The receive mixer and diplexer filter may be housed in one enclosure, as shown in Fig. 59. The SRA-1H is best mounted on top of the circuit board with the pins protruding through to the component side. Carefully mark and drill eight holes using a no. 59 drill bit. All holes on top of the board are deburred with a 1/8-inch drill; turn the bit by hand to remove the copper from around the hole. This allows ample clearance where leads are close to touching the board. Deburr the holes for pins 1, 3, 4 and 8 on the component side of the board. The other pins are ground and should be soldered directly to the ground plane.

Transmit Converter

Construction of the transmit converter requires a little extra planning for component layout because of the number of stages involved. Position the SRA-1 and the transistors to allow sufficient room for remaining components. It is better to allow extra room than to be cramped for space. Refer to Fig. 60 for ideas on board layout.



...s — The transmit converter incorporates extensive bypassing and shielding. J1 and J2 are at the bottom left. Q1, Q2 and Q3 are arranged ...g the lower edge of the board, below the horizontal shield. Q4 and Q5 are above that shield; Q4 is to the right. The two emitter leads of Q5 are ...ered directly to the ground plane near the center of the board. The lowpass filter is between Q5 and the output connector.

...ill any mounting holes as you go ...ng. Start by mounting the SRA-1 using ...ame technique described above. Then ...unt J1 and J2. Build the mixer band- ...s filter first, and then work stage-by- ...ge toward the output.

...1, Q2 and Q3 should be shielded by ...ing a small piece of sheet metal or ...ble-sided circuit-board material over ...h transistor. Cut a U-shaped notch in ...e shield to clear the transistor case. Each ...ld may be soldered directly to the ...und plane. Q1 and Q2 are mounted "...ls up," while Q3 and Q4 are mounted "...nt side up." Cut the Q3 and Q4 emit- ...ad to ⅛ inch before soldering the tran- ...tor in place. Note that Q1 and Q2 have ...r leads; one is tied directly to the tran- ...tor case and must be soldered to the ...und plane. The case of Q3, however, is ...nected to the collector, so be sure to ...e adequate clearance between the case ...the shield. Q4 must have a push-on, ...ed heat sink. The heat sink should not ...h any other components. Again, keep ...leads as short as possible.

Q5 is a stud-mounted power transistor. ...ll a hole just large enough to pass the ...aded stud and transistor base through ...circuit board. The emitter leads should ...almost flat on the component side of ...board. Cut the collector and base leads ...half of the original length, while leav- ...g the emitter leads full length. The heat ...k for Q5 is made from a U-shaped piece ...brass sheet (the same material used for ...circuit-board shields). Mount D1 on top ...the heat sink for good thermal contact; solder the ground end of D1 directly to the heat sink.

The value of R1 must be determined experimentally. Start with a 68-ohm, 2-W resistor. Measure the quiescent current of Q5 by inserting a milliammeter in the circuit at the cold end of L8. The quiescent current should be between 20 and 40 mA; adjust the value of R1 until proper bias is achieved.

The transmit converter is tuned by applying 12.5-V dc, LO energy and a 28-MHz signal attenuated to provide −10 dBm at the mixer input. Peak the double-tuned filter for maximum 220-MHz (or 144-MHz) output. If a spectrum analyzer is available, tune for a balance between maximum 220-MHz (or 144-MHz) energy and minimum spurious output. Next, peak C1 through C3. Alternately peak C5 and C6 for maximum output. C7, C8, C9 and C10 are adjusted in the same manner. Although a wattmeter may be used for tuning purposes, a spectrum analyzer tells the full story. Tune each stage for a compromise between output power and spectral purity.

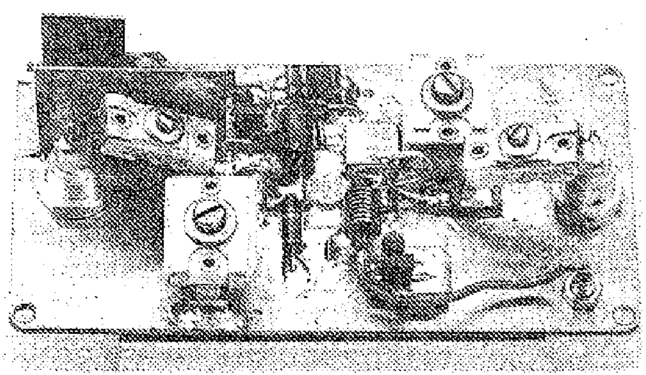


Fig. 61 — Space is a bit tight, but the 10-W amplifier will fit inside a small diecast box. Q5 is mounted at the center of the board. Input circuitry is to the left, output to the right. Q4 and associated bias circuitry are behind the shield adjacent to J1.

Harmonics are 60-dB down after filtering. After you're through adjusting the transmit converter, power output should be 1 watt.

Power Amplifier

The 10-W amplifier shown in Fig. 61 is mounted in its own diecast box. Ground feedthroughs are used beneath the 2N5946 emitter leads and at all variable capacitor grounds. The LM317 regulator IC must be attached to a heat sink. Bias should be adjusted for a quiescent current of 40 to 60 mA.

C5, C6 and C7 are Unelco metal-clad book-mica capacitors. These capacitors provide an excellent low-impedance RF ground and are designed to work at high-current points. For stable operation, it is important that you use book-mica capacitors at these points.

The heat sink is fashioned from two U-shaped pieces of aluminum sheet. Be careful when mounting the heat sink; lateral pressure on the 2N5946 stud may break the transistor.

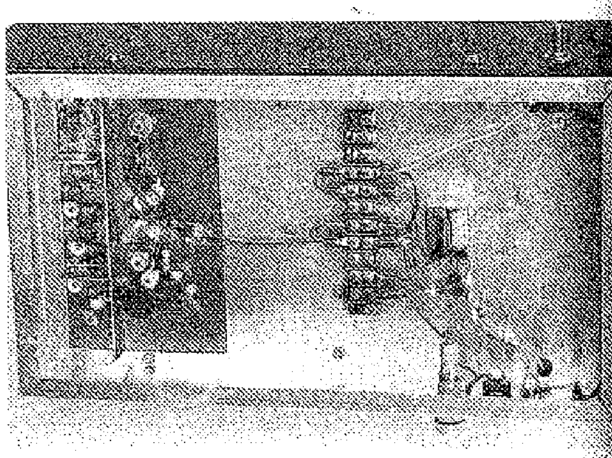


Fig. 62 — The transmit converter is mounted in a cutout portion of the chassis, component side down. Dc for the transmit and receive chains is brought in to K1 and from there to a barrier strip. Wires are routed from the barrier strip to each module.

Summary

The transverter modules are arranged on a chassis as shown in Figs. 46 and 62. Short runs of 50-ohm coaxial cable interconnect the units. Most of the dc power wiring is done underneath the chassis.

The 144/220-MHz transverter represents a low-cost, modern approach to getting on the VHF bands. Circuit construction is straightforward, and the design makes use of commercially available parts. The modular construction approach offers flexibility for easy troubleshooting and experimentation.

The author wishes to thank Ron Whitsel, WA3AXV, and other members of the Mount Airy VHF Radio Club "Packrats" whose encouragement made this project possible.

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